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Will Canopy-Embedded Mild Detonating Cord Affect Aircrew Visual Performance?

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13. ABSTRACT *(Maximum 200 Words).* Mild Detonating Cord (MDC) in the next generation transparency can significantly improve aircrew ejection separation times. Embedded as quarter-inch thick lines outlining the ejection zone, the MDC explosive can rapidly fracture the boundaries of this zone in half. These sections open upward and outward as the ejection seat penetrates the canopy. MDC thus eliminates the need to jettison the canopy prior to ejection, preserving the critical escape time requisite for aircrew survival. Unfortunately, aircrew visual performance may suffer as a consequence of installing MDC. Necessarily, MDC is a canopy visual obstruction that may interfere with target detection and tracking. Consequently, it is prudent to identify and characterize the potential negative visual performance consequences of installing MDC, then minimize them prior to canopy production. This paper presents the most relevant results of an extensive search and analysis of research findings suggesting possible visual performance effects associated with canopy-embedded MDC. Visual processes (e.g., accommodation) may interact with MDC characteristics (e.g., placement) and environmental conditions (e.g., low illumination) to create varied visual performance consequences. Under certain inter-actions of visual, MDC, and environmental variables, MDC may become visually prominent, "trapping" aircrew visual attention, thereby interfering with target detection, perception, and tracking.

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WILL CANOPY-EMBEDDED MILD DETONATING CORD AFFECT AIRCREW VISUAL PERFORMANCE?

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ABSTRACT

Mild Detonating Cord (MDC) in the next generation transparency has provided the opportunity for significant improvements to aircrew ejection separation times. Embedded as quarter-inch thick lines outlining the ejection zone, the MDC explosive can rapidly fracture the boundaries of this zone in half. These sections open upward and outward as the ejection seat penetrates the canopy. MDC thus eliminates the need to jettison the canopy prior to ejection, preserving the critical escape time requisite for aircrew survival.

Unfortunately, aircrew visual performance may suffer as a consequence of installing MDC. Necessarily, MDC is a canopy visual obstruction that may interfere with target detection and tracking. Consequently, it is prudent to identify and characterize the potential negative visual performance consequences of installing MDC, then minimize them prior to canopy production. This paper presents the most relevant results of an extensive search and analysis of research findings suggesting possible visual performance effects associated with canopy-embedded MDC.

Visual processes (e.g., accommodation) may interact with MDC characteristics (e.g., placement, contrast) and environmental conditions (e.g., low illumination, homogenous visual field) to create varied visual performance consequences. Under certain inter-actions of visual, MDC, and environmental variables, MDC may become visually prominent, "trapping" aircrew visual attention, thereby interfering with target detection, perception, and tracking.

INTRODUCTION

The ejection process must separate the aircrew from the aircraft nearly instantaneously, as a split second reduction in ejection time can be life saving. Precious time can be preserved by employing a through-the-canopy ejection strategy that eliminates the need to jettison the transparency prior to aircrew-aircraft separation.

This through-the-canopy ejection demands a successful canopy fracturing method. Canopy-embedded MDC presently offers the opportunity to reduce the egress times associated with the jettison of next generation, structurally robust transparencies. MDC, placed as quarter-inch thick lines determining the boundary of the canopy ejection zone, is simple, lightweight, and reliable. It is effective at rapidly severing the canopy, and allows escape in a variety of attitudes at nearly any altitude.*

Despite its advantages, MDC represents an additional visual obstruction in the pilot's field-of-view. In past canopy designs, the MDC obstruction may have been largely masked by structure, such as canopy bows and posts. However, in the next generation

* In addition to MDC, other types of explosives, like linear shape charge, could also be used and this type of charge works more effectively when mounted on the surface of the canopy. Either way, lines will be needed to detonate the charges. For the purpose of this paper we have focused on MDC, since it is representative of the type of explosives necessary to fracture the transparency for ejection.

transparency, which incorporates a high visibility windshield and canopy as an integrated frameless unit, MDC may prove more visually salient (i.e., more notable, conspicuous, or striking).

The next generation transparency's one-piece canopy structure, independent of any frames or stiffeners, is superior *because* of its relatively unrestricted field-of-view; accordingly, it is expedient to define and minimize the visual performance effects associated with canopy-embedded MDC. The purpose of this paper is to reflect our present exploration of the potential visual performance consequences of embedding MDC in the relatively unobstructed next generation transparency, and to provide a background for follow-on work needed to minimize MDC-related visual performance decrements.

FINDINGS

Canopy Structure and Blind Spots. Not long ago, lines in the visual field might have been considered insignificant in affecting cockpit vision. Indeed, the greater problem was preventing vision from being fully blocked by canopy structure.

When dealing with large canopy visual obstructions, such as structural posts or bows, provision for each eye's blind spot was, and is, crucial. Each eye has a blind spot where the optic nerve intersects the retina. No visual receptors (i.e., no rods or cones) populate this area, and so no visual information can be transmitted to the brain. Generally, vision from the other eye and synthetic visual construction from the brain fills in the gaps. Hence, the blind spot is often not apparent, even when viewing monocularly.

Regardless of its apparent perception (or lack thereof), the blind spot is there, and "The blind spot, while of relevance at all times when flying visually, is of special significance in cruise flight where it may cause conflicting traffic to be missed" (Hawkins, 1987, p. 119). In cases where structure prevents binocular vision, traffic can easily hide in the blind spot of the single eye that might have been able to see the traffic.

Under most viewing conditions, however, MDC will probably not cause pilots to miss targets because of ocular blind spots. MDC is expected to subtend a small visual angle, and will not likely present the magnitude of visual obstruction found with the structure that pilots normally encountered in the past. MDC may therefore seem to be a "nonobstruction" of sorts. As such, its visual effects are generally not addressed by relevant human factors military standards, which provide broad guidelines to prevent gross visual obscuration.

Still, we have reason to believe that MDC may impact aircrew visual performance based upon several interesting visual phenomena. Research on the resting point of visual accommodation, and accommodation's bias to this resting point under certain conditions, may provide some insight into the possible visual effects elicited by MDC.

Accommodation's Dark Focus. Accommodation is the ability to clearly resolve visual targets; simply put, accommodation is the eye's focus, and its accuracy varies greatly over individuals. Myopic, or nearsighted, individuals can accommodate near targets well, but fail to clearly focus far targets. Hyperopic individuals, on the other hand, can focus on far targets, but not near targets. Emmetropic, or normal-sighted people, can accommodate both near and far targets. Of course, because of intense screening, most pilots are emmetropes, and they have superior target acquisition and tracking skills.

Normal human accommodation ranges from about 4 - 8 inches (10 - 20 cm) at the near point to 20 feet (6 m) at the far point. The far point of 6 meters is designated as optical infinity, as accommodation beyond this point will not significantly increase the focal clarity of distant objects beyond this point. Accommodation's resting point (or "dark focus"**) was commonly believed to be this far point, until it could be demonstrated otherwise in the 1970's. The find-

** Dark focus is the distance to which the eyes focus in complete darkness, when no accommodative stimulus is present. Dark focus is generally equivalent to the resting point of accommodation.

ings regarding the eye's dark focus are central to the discussion of visual effects related to MDC.

But why is the dark focus of accommodation relevant to the case of canopy-embedded MDC? The answer is that the eye is biased toward this resting point, and under certain combinations of MDC and environmental conditions, the eyes may seek out this dark focus distance rather than focus on targets at infinity.

Leibowitz and Owens (1978) demonstrated that the mean dark focus of college students (n = 220) was not infinity, but 1.52 diopters[***] (focal distance = 67 cm) with high variability (standard deviation = 0.77 D) between subjects (dark focus ranged from 0-4 diopters). They concluded that their findings supported an *intermediate* dark focus (i.e., a resting point somewhere in between the near and far points). Owens (1979) later reported that dark focus "...was found to have an average value of 1.7 diopters (corresponding to 54 cm) among college-age observers" (p. 646). Other studies place the mean dark focus distance between 1.0 and 2.25 diopters, and confirm that individuals vary greatly in their dark focus distance.

For a given individual, though, dark focus distances are stable over long periods of time, with short-term fluctuations (Swanson, 1989). Overall, a good rule-of-thumb is that dark focus distance equals arm's length (Simonelli, 1983).

Given the demonstrated intermediate value of dark focus, accommodation can be conceptualized as "positive" (increased refractive power) and "negative," (decreased refractive power) with the intermediate point lying somewhere in between. Without positive or negative accommodation to a stimulus, this intermediate point would represent the passive resting point (Leibowitz and Owens, 1978).

Night and Empty-Field Myopias. As examples of environmental conditions stimulating a dark focus response, consider the cases of night myopia and empty-field myopia. In the best of eyes, myopia, or nearsightedness, may occur temporarily because of accommodative responses to the environment and visual stimuli, in addition to ocular defect causes. These myopias, dependent upon the viewing situation, have been termed *anomalous* myopias. Of the anomalous myopias, night myopia and empty-field myopia are highly important for the present purpose.

The British astronomer Nevil Maskelyne noticed that he needed corrective lenses (for nearsightedness) to make accurate night astronomic observations, and was the first person credited with documenting the phenomenon of night myopia (Swanson, 1989). Whereas in daytime the myopic correction would provide no help, at night, this correction became a necessity (Owens, 1984). Night myopia is associated with low environmental illumination, and induces the eye to accommodate to the dark focus. Owens and Leibowitz (1976) found a night myopia accommodation level ranging from 0.5 D to 2.5 D. Night myopia was also closely correlated with an individual's dark focus distance; individuals with a close dark focus experienced proportionately more night myopia than individuals with a far dark focus.

As with the night anomalous myopia, empty-field myopia is inextricably linked with the viewer's dark focus. In a visual field which provides no stimuli for accommodation, such as a clear sky (or even a clear sky with low-contrast features), viewer accommodation reverts to the dark focus. Whiteside (1957) provided valuable evidence for this phenomenon, and also provided support for the intermediate resting focus theory at a time when infinity was the accepted resting point of accommodation. Whiteside (1957) wrote,

> It was shown that in the presence of an empty visual field, subjects cannot relax accommodation completely. Accommodation is shown to be in a state of constant activity fluctuating about a level of 0.5-2 diopters,

[***] Accommodation, as well as lens power, is measured in diopters (D). A diopter is a measure of refractive power, defined as the reciprocal of the focal length in meters. For instance, a focal length of two meters is equal to .5 D (1 ÷ 2 meters = .5 D).

> sometimes approaching the far point but never quite reaching it.
>
> The subject with normal eyesight is thus unable to focus at infinity if there is no detail at infinity which is capable of being sharply focused. Under these conditions, the furthest he can focus is a point about 1-2 meters away. He thus becomes effectively myopic by this amount. Attention is drawn to the similarity between this new phenomenon, and that known for some years under the name of night myopia. (p. 92)

Hence, in an empty field, focus does not relax to infinity, but rather reverts to the dark focus. Leitner and Haines (1981) wrote, "under these lighting conditions [EF myopia], the magnitude of accommodation is either the same as the dark focus (resting state) response or at an intermediate distance between the dark focus distance and the stimulus distance" (p. 1).

Leibowitz and Owens (1978) explained the relationships they found between dark focus and the anomalous myopias; "In accord with the intermediate resting state hypothesis, these results imply that the eye assumes an individually determined, intermediate focus whenever variations in accommodation produce no change in the retinal image" (p. 138). These researchers explained the anomalous myopias "as the passive return of accommodation to the intermediate dark focus" (p. 139). Essentially, these anomalous myopias are indicative of an absence of accommodative response. In general, the focus distance while experiencing an anomalous myopia is about arm's length, varying with the individual.

The discussion of the eye's resting point bias (illustrated via the anomalous myopias) serves as background to understanding potential effects of canopy-embedded MDC. Understanding the eye's dark focus bias is central to appreciating the following discussion of the Mandelbaum effect. This effect is an important visual phenomenon that may partially explain the results observed from embedding lines in the aircrew's field-of-view.

The Mandelbaum Effect and MDC. While at his summer cottage, the ophthalmologist Joseph Mandelbaum noticed that he could not clearly focus on a "No Swimming" sign while viewing it from his screened-in porch, at a particular near distance. This effect was strange, because Mandelbaum could clearly focus the sign outside of his porch, and even at some other places inside the porch (Owens, 1984). His focus was effectively "captured" by the screen, rendering accommodation (focus) beyond the screen practically impossible.

Mandelbaum tested and replicated the phenomenon on family and friends, finding a critical screen-to-viewer distance that mediated accommodation (Owens, 1984). This phenomenon was later named the Mandelbaum effect. The Mandelbaum effect is a trapping of accommodation at a close distance, induced by an interposed surface. In effect, the interposed surface becomes an obligatory visual stimulus, and accommodation is subsequently, involuntarily drawn to the nearer texture.

Mandelbaum tested 21 observers viewing a distant (225 ft.; 78 m) sign (with letters 5 in.; 13 cm high) through a screen-enclosed porch. He found,

> ...that the effect of the screen in 'capturing' accommodation and blurring the distant sign was critically dependent upon the distance of the screen from the eyes. The region of maximum blur of the sign occurred when the screen was an average of 1.37m (4.5 ft., .73 D) from the eyes. (Randle, 1988, p. 213)

The Mandelbaum effect is most pronounced when the distance from the eye to the interposed surface is equivalent to the dark focus (Owens, 1979). Norman and Ehrlich (1986) conclude, "This appears to indicate that it is the tendency of the accommodative mechanism to revert to the RPA [resting point of accommodation] that is reinforced by the interposing screen, thereby rendering the eyes temporarily myopic" (p. 136). Owens (1979) states,

> If this viewpoint [the intermediate dark focus theory] is correct, the Mandelbaum effect might be parsimoniously explained as an involuntary focusing preference for objects lying near the observer's characteristic dark-focus distance. When confronted with two superimposed stimuli, one at the dark focus and one at some other distance, accommodation would show a bias toward that at the dark focus. (p. 646)

Mandelbaum found considerable individual differences in the critical distance from the subject to the screen (Benel, 1980). This further suggests that the Mandelbaum effect's critical distance may vary with individual dark focus. Owens (1979) stated, "Since the distance of the dark focus varies across observers, the distance at which the unattended stimulus interferes with the voluntary control of accommodation would be expected to show similar interobserver variation" (p. 646).

Even without embedded lines, automobile and aircraft transparencies invite the Mandelbaum effect, as the shields are often placed at a distance that corresponds to the dark focus of many individuals. With dirt, rain, bug splats, and scratches, a windshield becomes increasingly an accommodation trap (Owens, 1984). Hawkins (1987) stated, "The ability to detect outside objects when there is rain or other contamination on the windscreen can also vary considerably between individuals" (p. 106).

Of particular relevance to canopy-embedded MDC, the Mandelbaum effect may not be limited to foveal vision. In the absence of foveal accommodative cues, or in situations where distance cues conflict, Hennessy and Leibowitz (1971) suggested that peripheral visual cues might dominate the accommodation of the eyes. For instance, in high altitude flight, an empty or homogenous visual field prevails, providing the eyes with few visual cues. In this situation, pilots may accommodate to non-foveal cues, such as canopy structure, or in the case of the next generation transparency, the MDC (Matthews, Angus, and Pearce, 1978). Such a misaccommodation effectively equals a visual acuity loss; aircrew may consequently fail to visually acquire distant targets.

Acuity loss is not the only problem associated with close capture of accommodation. The Mandelbaum effect may also interact with the perceived size of distant objects. When attention is drawn inward, distant objects appear smaller. Benel (1980) cited the experience of monocularly viewing a distant target, and then focusing on one's finger placed in front of the eye. Perceptually, the distant target shrinks in size as the eye accommodates to the closer object (the finger). Applying this experience to MDC placed in the pilot's visual field, distant targets may appear perceptually smaller in relation to the MDC, not just because of a size contrast, but particularly because the cutting cord is being accommodated.

Benel (1980) demonstrated that a Mandelbaum-type screen's distance affected accommodation and apparent size, stating, "...the distance to which an observer is accommodated is a real, quantifiable correlate of apparent size" (p. 334). He summarized, "A small change in the accommodative draw of an interposed surface may be sufficient to change the apparent size of an object even with all other factors held constant" (p. 334). Benel proposed that aircraft landing approaches might be problematic because of the apparent size shift of the runway.

Pilots can "learn" (i.e., force themselves) to overcome the Mandelbaum effect, but exerting volitional control over accommodation requires concentrated attention. Owens (1984) stated that such control might be very difficult to maintain and transfer to real situations (p. 383).

Edgar, Wolffsohn, and McBrien (in press) advocated a simple system that both warns the pilot of inappropriate accommodation and aids the restoration of correct accommodation via volitional control. Their Warning of Inappropriate Visual Accommodation Response (WIVAR) system employs two uncollimated vertical lines, projected at the HUD combiner glass level, which can be visually perceived as up to four blurred lines, depending on focus. For instance, with accommodation at infinity, the two lines should appear as four blurred lines that draw little or no

attention. With a close focus, however, the two lines should be perceived as two sharp lines. Using these cues, the aircrew is thus able to appreciate and correct inappropriate accommodation; the authors reported very encouraging initial results associated with their experimental testing of the WIVAR system.

Benel (1980), in addition to several other researchers, advocated a selection and optical correction proposal for dark focus. He suggested that vehicle operators could be selected based on their dark focus distance, or given dark focus correction for the Mandelbaum effect. "Specifically, a 'corrected' dark focus beyond windscreen distances would all but eliminate accommodative 'trapping'" (p. 335). However, for the designers of the next generation transparency, the goal is to minimize the visual effects of MDC regardless of any (unlikely) changes to aircrew selection or visual correction doctrine.

As an alternate position on the effects of an interposed surface, some researchers feel that an interposed screen or texture may actually assist with target detection. Discussing motion parallax, Hill and Markus (1968) noted that, "Movement of the head in a fronto-parallel plane produces motion parallax between the mesh screen and a distant object which, by temporal integration of transmitted information it is reasonable to assume will improve visibility of the object viewed through the mesh." Essentially, when one uses a foreground object as a reference and moves the head from side to side, relative motion between the foreground and background objects can make the background objects more apparent.

In a test of vision through panels of varying inclusions, Kama and Genco (1982) found that the size and number of windscreen inclusions did not affect target detection performance using 1.0 minute, high-contrast targets. Interestingly, performance with the more-occluded panels was in some cases superior to performance with a zero-defect panel. Kama and Genco (1982) suggested that the subjects moved their heads right and left, using the defects to create a motion parallax, so that distant objects could be discerned via their relative motion with close objects. Kama and Genco (1982) concluded, "Indeed, these defects may improve target localization in some cases by providing a reference for parallax motion cues" (p. 18).

Search for Empirical Evidence. Given these at least partially divergent views on potential effects of interposed stimuli on the visual perception of distant objects, we sought to uncover real-world consequences related to interposed visual stimuli. We searched the Air Force, Navy, and NASA Aviation Safety Reporting System (ASRS) databases, using a robust search strategy developed from database thesauri, key articles, and expert opinion.

Air Force Safety Center Search. The search of the Air Force Safety Center databases covering the period from 1971 through June 1997 revealed no reported accidents or incidents relevant to the placement of MDC in the aircraft canopy. In an official communication to Mr. Frank C. Gentner (21 July 1997), Lt Col J. C. Neubauer explains,

> I used your recommended list of terms to do a word search of mishap narratives. In addition, I included the terms visual focus, visual obstruction, visual illusions, visual distraction and distraction. I found no mishaps that suggested visual trapping or distraction that led to a mishap. I also performed a search on the human factor "visual acquisition," the closest term we have to address visual trapping. Again, I was unable to find any mishaps that fall into the perimeters you requested.

Naval Safety Center Search. A similar search of the Naval Safety Center database, covering the period from calendar year 1980 to May 1997 yielded no evidence of mishaps relevant to the placement of MDC in the canopy. R. H. Dougherty (official communication to Mr. F. C. Gentner, 29 May 1997) explains,

> Queries were specifically directed to reportable incidents involving causal factors that addressed mild detonating cord placement,

HUD/HMD involvement and/or obstructing structure effects. No attributable factors or port-mishap recommendations based on these arguments were revealed.

NASA ASRS Search. Our search of the NASA ASRS incident database (covering the time frame from January 1988—June 1997) revealed 44 incident reports (out of a possible 58,168 full-form reports); of these, 41 were relevant to windshield visual obstructions. Table 1 categorizes these 41 reports and rates their relevance to the placement of MDC in the NGT.

Table 1. NASA ASRS summary findings and relevancy to MDC effort.

Category	Count	Relevance		
		Low	*Med*	*High*
Structure blocking	23		✓	
Glass clarity impaired	10	✓		
Glass clarity blocked	3	✓		
Glare / Reflection	3	✓		
Mandelbaum Effect?	1		✓	
Distance Illusion	1		✓	
Total Records	41			

By far, problems with aircraft structure dominated the reports. Pilots reported that windshield posts, overhead structure, and attachment structure (e.g., compass attachment structure) interfered with traffic detection. Although MDC is an added windscreen obstruction, it will probably not create the detection problems associated with large areas of aircraft structure. Accordingly, these reports may have limited applicability to the current NGT inquiry.

A number of other reports cited problems with visibility through the transparency, from a variety of causes, including dirt, ice, rain, direct sun, and windscreen crazing. In some cases, the clarity of the glass was impaired, and in other cases, the whole windscreen was blocked (e.g., one pilot experienced an oil leak that completely covered the windshield). It would be inappropriate, however, to suggest that any of these incidents indicate how MDC might impact visual performance.

Two reported incidents, however, did cite problems that might also be present with MDC. In report #172353, the pilot states, "RWY [runway] 23 at crew slopes uphill, giving the illusion of being high on the APCH [approach]. Rain on the windshield enhances this effect." MDC will not be located in the approach field-of-view, but may create an illusion of greater distance when the pilot looks up or to the sides, where MDC will likely be located.

In report #139629, the pilot may be alluding to the Mandelbaum effect, stating, "With rain effect on windshield, did not notice markings or lack of lights." The reader of this report is left to infer what is meant by "rain effect;" assuming a Mandelbaum effect translation, the rain created a focal stimulus that consumed the pilot's attention. If MDC is a strong enough visual stimulus, there is a chance that it could create a similar attention and accommodation trap.

The other reports from the ASRS search were not at all relevant to any windshield obstructions. Hence, they have no applicability to the visual effects of MDC.

MDC from a Systems Perspective. Since definitive answers on the visual performance effects of MDC are not forthcoming, we have elected to hypothesize effects that are likely from the interactions of MDC and the total canopy system in which it is immersed. As a caution to this process, Weintraub and Ensing (1992) noted that, "An important point worth reiterating is that theorizing and laboratory evidence based upon laboratory phenomena may apply poorly to the real world" (p. 90).

Overall, we must recognize that dark-focus phenomena occur whether or not MDC is present, with canopy imperfections, in reduced luminance, and in empty visual fields. Our specific concern is whether MDC escalates or otherwise contributes to the dark-focus-related visual capture phenomenon. Accepting this emphasis, a number of caveats involving

MDC human factors system variables must be appreciated before assessing the visual impact of the MDC.

To some extent, the canopy always interferes with aircrew visual perception. Kraft, Anderson, Elworth, and Larry (1977) discuss some of the necessary canopy-related visual challenges that aircrew must face:

> The aerodynamic and structural considerations have imposed the requirement that windscreens be thick, multi-layered, coated, curved and slanted backward at a very shallow angle. These characteristics, in turn, have increased the visual problem by adding windscreen inclination displacement, attenuation of illuminance, angular and curvilinear deviations, internal reflections, multiple images and haze. (p. 9)

Given these other visual effects, the concept of a *visual attention threshold* is useful in considering what effect MDC might have on the aircrew. If MDC is below any perceptible visual attention threshold, then it will probably have no effect on the aircrew. Moreover, if other windshield characteristics such as reflectance or glare are more evident than the MDC, then the MDC will probably have no effect on the aircrew. Conversely, if MDC is above a perceptible visual attention threshold, and adds to or interacts with the effects from other canopy characteristics, then it may impact aircrew visual performance.

The environmental illuminance and visual detail may also interact with MDC to affect accommodation (conscious or unconscious). For instance, in empty field conditions, enhanced salience of the MDC may act to keep focus at a close level (thus exacerbating empty-field myopia effects), making target detection very difficult. However, night myopia will probably not interact with MDC to draw focus inward. Although reduced illumination induces an accommodative response toward the dark focus, the reduced illumination will also decrease the contrast ratio between the MDC and the outside environment (assuming the MDC is gray or black). This contrast reduction will reduce the "pulling power" of the MDC, reducing its effect as an obligatory stimulus. More importantly, at a practical level, many nighttime tasks are performed "eyes in" rather than "eyes out;" hence, the visual effects of MDC at night may not be as important as its daytime effects.

CONCLUSION

Although no past research has directly addressed the visual performance effects of canopy embedded MDC, a number of conclusions may be suggested. MDC:

- may activate the accommodative bias toward the dark focus; past research does not clearly delineate the precise effects.
- will likely be more salient, and hence provide a stronger accommodative draw, during daylight, empty field conditions.
- intersecting the dark focus distance risks inappropriate accommodation more than placement of MDC at other distances
- may not affect visual performance if it remains below a (presently undefined) visual attention threshold.
- may not affect visual performance if it is overshadowed by other visual effects associated with the canopy alone.

Given the potential for negative visual performance effects and aircrew dissatisfaction, it is prudent to characterize and minimize the effects of MDC *prior* to canopy production. For this purpose, an experiment is presently being planned at CSERIAC, to clarify the visual performance effects of MDC in the next generation transparency.

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